

means for depositing a thin film on the substrate at said low deposition rate from said reaction of said deposition gases.

REMARKS

Claims 1-10 and 44-62 are pending. Claim 4 has been amended to correct minor informalities. No new matter has been introduced. Applicants believe the claims comply with 35 U.S.C. § 112.

Claims 44, 45, and 62 stand rejected under 35 U.S.C. § 102(b) as being anticipated by Felts et al. (USP 4,888,199), as demonstrated by M.K. Puchert et al.

Applicants respectfully assert that independent claim 44 and claim 45 depending therefrom, as well as independent claim 62, are novel and patentable over Felts '199 because, for instance, Felts '199 does not teach or suggest adding a flow of an inert gas to the selected deposition gases at a flow rate previously determined to achieve a desired low deposition rate from a plasma enhanced reaction of the selected deposition gases, wherein the desired deposition rate is lower than a deposition rate using the selected deposition gases at the deposition gas flow rates with a lower flow rate of the inert gas.

The Examiner alleges that Felts '199 anticipates the claimed relationship of deposition rates and that "the addition of He increases electron density in the plasma (column 10, lines 47-50) which anticipates the effect of reduced deposition rates considering the fact that these added electrons would effectively shield cations thereby reducing one of the chemical mechanisms of PECVD." The Examiner's statement is without merit. Felts '199 discloses the use of the average electron temperature of the plasma T_e to diagnose and control the plasma deposition. "The average electron temperature of the plasma affects the film deposition rate and properties of the resulting film, so it is an important piece of information to have in a real time plasma control system." Column 2, lines 47-51.

There is nothing in Felts '199 that suggests "added electrons would effectively shield cations thereby reducing one of the chemical mechanisms of PECVD," as alleged by the Examiner. Nor does Felts '199 suggest controlling the gas delivery system to add a flow of an inert gas to the selected deposition gases at a flow rate previously determined to achieve a desired low deposition rate from a plasma enhanced reaction of the selected deposition gases, wherein the desired deposition rate is lower than a deposition rate using the selected deposition gases at the deposition

gas flow rates with a lower flow rate of the inert gas, as recited in claim 44. In contrast, Felts '199 is concerned with achieving a desired average electron temperature of the plasma (col. 2, line 58, to col. 3, line 6):

By taking another ratio of two emissions lines, one produced by a species that necessarily absorbs a high energy from electron collisions with it and another from a species having a probability of having absorbed much lower energy from electron collisions with it to give the measured emission, a declining "tail" of an electron energy (temperature) distribution within the plasma can be monitored and controlled. It has been found that high energy electrons in the plasma can inadvertently be suppressed in the course of optimizing other variables. Therefore, a separate high energy electron density measurement reveals whether this is happening or not and allows an adjustment to be made in real time to maintain a sufficient proportion of high energy electrons in the plasma. An adequate supply of high energy electrons is important to the hardness of the resulting film.

The Examiner cites Puchert et al. for allegedly demonstrating the relationship between plasma vapor deposition and He electron density. Puchert et al. discloses a decrease in deposition rate of copper as the pressure and ion current increase.

Puchert et al., however, is directed to "the interaction between the metal plasma beam of a filtered cathodic arc and the noble gases helium neon, and argon introduced into the beam path" (page 3493, col. 1, lines 27-30). **There is no basis to believe that the results of copper deposition from a metal plasma beam of a filtered cathodic arc can be generalized to plasma-enhanced chemical vapor deposition (PECVD) of a dielectric layer.** The deposition mechanism, deposition apparatus, nature of film deposited are **fundamentally different**. The Examiner's assertions are based on nothing more than speculation. ✓

Indeed, a more relevant reference discloses deposition of a PECVD silicon nitride layer from SiH_4 , N_2 , and He, in which the deposition rate is positively related to the inert gas flow rate. See D.V. Tsu et al., "Local Atomic Structure in Thin Films of Silicon Nitride and Silicon Diimide Produced by Remote Plasma-Enhanced Chemical-Vapor Deposition," Physical Review B, 7069-76 (May 15, 1986). This reference was cited in the IDS filed on December 27, 1999. This is

directly opposite from the claimed invention of depositing a PECVD layer from SiH_4 and N_2O in which the deposition rate is inversely related to the inert gas flow rate. Tsu et al. discloses the positive correlation of inert gas flow rate (He) and silicon nitride film deposition rate in Tables I and II; page 7071, column 1, lines 1-29; and page 7072, column 1, lines 1-9. "Additional dilution with He serves to increase the deposition rate still further." Page 7071, column 1, lines 13-14. "Increased dilution of the N_2 with He increases the deposition rate by inhibiting recombination and/or deexcitation reactions involving collisions between N atoms and nitrogen molecules." Page 7072, column 1, lines 6-9.

Therefore, the effect of helium dilution cannot be generalized based on Puchert et al., particularly since the deposition mechanism, deposition apparatus, nature of film deposited are fundamentally different. Therefore, claims 44, 45, and 62 are novel and patentable.

Claims 1 and 7 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over Felts et al. (USP 5,365,665).

Applicants respectfully submit that independent claim 1 and claim 7 depending therefrom are patentable over Felts '665 because, for instance, Felts '665 does not teach or suggest computer readable program code for causing the gas distribution system to introduce a second process gas comprising He into the chamber to control the deposition rate of the first layer. ✓

The Examiner cites Felts '665 at column 5, lines 13-20, 42 for allegedly anticipating this feature of the claim. Felts '665 merely discloses the use of an inert gas (helium or argon) with an organosilicon compound and oxygen of the gas stream to deposit a film. Nothing in Felts '665 discloses or suggests introducing a process gas comprising He to control the deposition rate of the PECVD deposition layer from the recited process gases. Thus, claims 1 and 7 are patentable. ✓

Dependent claims 2-6 and 9 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over Felts '665 as applied to claim 1, and further in view of Dory (USP 4,877,641). Dory does not cure the defects of Felts '665. Therefore, claims 2-6 and 9 are patentable. 2.

Dependent claims 46-48 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over Felts '199 as applied to claims 44 and 45 above, and further in view of Felts '665. As discussed above, Felts '199 fails to teach or suggest computer instructions for controlling the gas delivery system to add a flow of an inert gas to the selected deposition gases at a flow rate previously determined to achieve a desired low deposition rate from a plasma enhanced reaction of the selected deposition gases, wherein the desired deposition rate is lower than a deposition rate ...

using the selected deposition gases at the deposition gas flow rates with a lower flow rate of the inert gas. Felts '665 does not cure this defect. Accordingly, claims 46-48 are patentable.

Dependent claims 49-52 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over Felts '199 as applied to claims 44-48 above, and further in view of Felts '665 and Dory. As discussed above, Felts '665 and Dory fail to cure the defects of Felts '199. Thus, claims 49-52 are patentable.

Claims 53-59 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over Felts '665 as applied to claim 49 above, and further in view of Felts '199 and Dory.

Independent claim 53 is submitted to be patentable because, for instance, the references do not disclose or suggest that a ratio of the selected flow rate of He to the combined flow rate of SiH₄ and N₂O is at least 6.25:1 to deposit an antireflective layer on the substrate at a deposition rate which is lower than a deposition rate using the same flow rate of SiH₄ and the same flow rate of N₂O with a lower flow rate of He. This feature is completely absent from the cited references.

Independent claim 54 is patentable because, for instance, the references do not teach or suggest computer instructions for controlling the gas delivery system to add a flow of an inert gas to the selected deposition gases at a flow rate previously determined to achieve a desired low deposition rate from a reaction of the selected deposition gases, wherein the desired low deposition rate is lower than a deposition rate using the selected deposition gases at the deposition gas flow rates with a lower flow rate of the inert gas. As discussed above, Felts '199 merely discloses the use of the average electron temperature of the plasma T_e to diagnose and control the plasma deposition. Felts '665 merely discloses the use of an inert gas (helium or argon) with an organosilicon compound and oxygen of the gas stream to deposit a film. Dory does not cure the defects of Felts '199 and Felts' 665. Accordingly, claim 54 is patentable.

Independent claim 55 and claim 56 depending therefrom are patentable because, for instance, the references fail to disclose or suggest means for adding a flow of an inert gas to the selected deposition gases at a flow rate previously determined to achieve a desired low deposition rate from plasma enhanced reaction of the selected deposition gases, wherein the desired low deposition rate is lower than a deposition rate using the selected deposition gases at the deposition gas flow rates with a lower flow rate of the inert gas. As discussed above, nothing in the references suggest this feature.

Independent claim 57 and claims 58-59 depending therefrom are patentable because, for instance, the references do not teach or suggest that a ratio of the selected flow rate of He to the combined flow rate of SiH₄ and N₂O is at least 6.25:1 to deposit an antireflective layer on the substrate at a deposition rate which is lower than a deposition rate using the same flow rate of SiH₄ and the same flow rate of N₂O with a lower flow rate of He. This feature is completely absent from the cited references. ✓

Claims 8, 60, and 61 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over Felts et al. '665 in view of Lee (USP 5,286,581). The Examiner alleges that Lee discloses that a first reflection from an interface between the photoresist layer and the antireflective layer of an exposure light is an odd number which is not at least 3 multiplied by 180° (π in radians) out of phase with a second reflection from an interface between the antireflective layer and the substrate layer of the exposure light. The Examiner further alleges: "Although Fourmun Lee teaches only $n\pi$ radians, wherein $n=1$, out of phase between consecutive areas 12' and 13', it would have been obvious to one of ordinary skill in the art at the time the invention was made to realize that odd multiples of π radians is the same phase angle."

The specification at page 10, line 14, to page 11, line 14, describes a number of advantages of using thicker antireflective layers by selecting a thickness that is an odd multiple, greater than one, of a wavelength of light to be used in a subsequent process operation on the layer. For instance, the increased thickness achieves improved film consistency from wafer to wafer; provides better control of the refractive index, absorptive index, and thickness of the film; and renders the film suitable for use as a hard mask during an etching step. These are not disclosed in Lee. Nothing in Lee teaches or suggests a thickness that is an odd multiple, greater than one, of the wavelength. Even if combined, therefore, Felts et al. '665 and Lee do not render claims 8, 60, and 61 unpatentable. } ✓

Furthermore, Lee does not cure the defects of Felts et al. '665, in that Lee also is devoid of any teaching or suggestion of introducing a second process gas comprising He into the chamber to control the deposition rate of the first layer, as recited in claim 1 from which claim 8 depends. Lee further fails to disclose or suggest adding a flow of an inert gas to the selected deposition gases to deposit the antireflective layer at a desired deposition rate which is lower than a deposition rate using the selected deposition gases at the deposition flow rates with a lower flow rate of the inert gas, as recited in claims 60 and 61.

CONCLUSION

In view of the foregoing, Applicants believe all claims now pending in this Application are in condition for allowance. The issuance of a formal Notice of Allowance at an early date is respectfully requested.

If the Examiner believes a telephone conference would expedite prosecution of this application, please telephone the undersigned at 650-326-2400.

Respectfully submitted,



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VERSION WITH MARKINGS TO SHOW CHANGES MADE

IN THE CLAIMS:

Please amend claims 4 as follows:

4. (Amended) A substrate processing system as in claim 3 wherein the computer readable program code for causing the gas distribution system to introduce the first process gas comprising a mixture of SiH_4 and N_2O into the chamber controls the introduction of the SiH_4 to be at a [ratio] volumetric flow rate of between 0.5 to 3 times the [amount] volumetric flow rate of N_2O .